Quarterly Progress Report #8

For the project entitled:

Field Evaluation of the Performance of Three Concrete Bridge Decks on Montana Route 243

Reporting Period: October 1, 2003 – December 31, 2003
(*Quarter 2, State Fiscal Year 2004*)

Summary of Expenditures

The table below summarizes the expenditures on this project through December 31, 2003. Expenditures during this quarter were $16,786.14, with total expenditures through December 31, 2003 equaling $244,557.44.

Budget Category	Spent through 12/31/03	Spent This Quarter	Total Spent
Salaries	$95,037.68	$10,168.84	$105,206.52
Benefits	$15,588.79	$1,627.24	$17,216.03
In-State Travel	$13,375.83	$1,397.36	$14,773.19
Expendable Supplies	$16,392.04	$548.35	$16,940.39
Tuition	$13,070.50	$278.00	$13,348.50
Reporting	$0.00	$0.00	$0.00
MDT Direct Costs	$153,464.84	$14,019.79	$167,484.63
Overhead	$26,324.46	$2,748.35	$29,072.81
MDT Share	$179,789.30	$16,768.14	$196,557.44
WTI Share (Equipment and Out-of-State Travel)	$48,000.00	$0.00	$48,000.00
Total	**$227,789.30**	**$16,768.14**	**$244,557.44**

As detailed in a memo written to Craig Abernathy on December 23, 2003, the work completed to date on the Saco Bridge Instrumentation project has cost approximately 50,000

dollars more than was anticipated in the proposal. In addition, it is anticipated that 10,000 dollars will be needed to cover underestimated future costs. The Civil Engineering Department at Montana State University is committed to providing 20% above what the Montana Department of Transportation puts toward the project. If the Research Review Committee approves our request of 50,000 dollars from MDT, then the goal of 60,000 dollars will be met.

In addition to increasing the budget, the schedule will also need to be extended in order to conduct the second round of live load testing two years after the first round. This extension will be discussed in more detail as the original end to the project (May 2005) is approached.

Task A: Project Management

Significant effort was spent this quarter on reviewing the project budget and schedule to determine exactly where cost overruns occurred and to determine how much additional funding and time is necessary to complete the remaining project activities. This information was presented to the project technical panel at a meeting in December. Following this meeting, a memo was prepared and sent to MDT summarizing the information. The memo also included a detailed itemization of what was budgeted, spent and needed in terms of labor, travel, supplies, and tuition.

Task B: Conduct Literature Review

The primary literature review for this project has been completed. Nonetheless, the time frame for this project is quite long, so information will continue to be collected throughout its duration. Information collected up to this point will be summarized in the interim report.

Action Items for next quarter:

- Continue collecting relevant literature
- Write up the literature review for the interim report

Task C: Develop Instrumentation Plan and Assemble Data Acquisition System

Determine Gage Locations

Information from the report documenting the process used to select the gage locations in each deck will be summarized and included in the interim project report.

Weather Station

The remote weather station continues to function well, collecting pertinent weather information every 15 minutes and automatically downloading it to a central, searchable database.

Bridge Monitoring Data Acquisition System

All three remote bridge monitoring data acquisition systems continue to function well, collecting strain and temperature information from the bridge decks at hourly intervals. Erratic readings from the Conventional bridge deck's vibrating wire sensors made it necessary to travel to Saco to rectify the problem. The problem was fixed, and the unresponsive sensors are now actively recording long term strain data.

Action Items for Next Quarter:

- Complete historical documentation and include this information in the interim report
- Preserve and maintain the accuracy of long-term monitoring system
- Maintain/download data from large vehicle events and compare to data from MDT portable WIM site and permanent classifier

Task D: Install Instrumentation and Compile As-Built Documentation

Instrumentation Installation

Electrical and communication cable, used to carry data and power from the utility pole to the data acquisition equipment under the bridge, were buried to protect them from being damaged in the future. PVC conduit was used to accommodate these cables under the bridge deck, but was buried directly in the soil from the deck to the utility pole. This work finalized the installation of all instrumentation and related hardware at the test site.

Materials Testing

During bridge construction, MDT performed air content tests, conducted slump tests, and collected compression test specimens from the concrete from selected concrete trucks. Results of these tests will be included in the project analysis and documentation. Mark Kurokowa (Engineering Project Manager – Wolf Point) was contacted this quarter to collect this information, and indicated that this information will be available near the beginning of next quarter.

Action Items for Next Quarter

- Continued periodic measurement of shrinkage specimens
- Collect material properties of the reinforcing steel and concrete from MDT (Mark Kurokowa)
- Document all material properties in a centralized database

Task E: Live Load Testing

During this quarter, analysis of the data collected during the live-load tests continued. As was discussed last quarter, the slow-speed live load data records must be zeroed and spatially

synchronized so that responses can be compared between sensors for an individual bridge and between bridges. This work was completed for all sensors. Templates were developed to graphically display measured responses along longitudinal and transverse gage lines in the decks. Individual responses from gages were also scrutinized to verify that their behavior coincided with expected results. As part of this process, the data was reviewed relative to its consistency for transducers in similar locations under similar load events. The results of this work will be detailed in the interim report.

Action Items for Next Quarter:

- Continue analysis of live load test data and document the results into interim report
- Process high speed test data to be included in the interim report

Task F: Long-Term Monitoring

Strain Monitoring

Approximately seven months of long-term data has been collected from selected sensors in each of the bridge decks. All the active long term sensors are currently set up to provide measurements once every hour. This data acquisition schedule has been interrupted on occasion due to maintenance and other activities. These interruptions are considered inconsequential in terms of the entire length of the project. The data available from the long term monitoring effort will be studied over the next several months to correlate changes in deck performance with the vehicle and environmental loads they experience, and then to further evaluate the relative performance of the three types of decks. Any significant conclusions to date will be summarized in the interim report.

Action Items for Next Quarter:

- Continue monitoring strains in the bridge decks
- Summarize findings in the interim report

Large Vehicle Event Monitoring

The data loggers have been monitoring large vehicle events throughout this quarter. An event is registered when strains reported by a "trigger gage" exceed an established threshold. Due to variations in the bridges' response to environmental and traffic loading, the threshold values used on each bridge are not the same. The early vehicle event data collected from each bridge was scrutinized relative to setting the individual triggers so that each bridge records the same events. Thus far, the trigger adjustment has been an ongoing activity as conditions at the bridges change. Table 1 summarizes the number of events captured from each bridge since this system was made functional. It is important to realize, however, that a majority of the events being captured correlate well across all three bridges. Figure 1 shows the typical response during

a large vehicle event. Large vehicle event data will be correlated to data obtained from the portable WIM and truck classifier during the coming quarter.

Action Items for Next Quarter:

- Continue collecting large vehicle event data
- Make comparisons between data collected from the bridges to data collected by the classifier and the portable WIM

Table 1: Summary of Large Event Data Collected on Saco Bridges

Date Range	# of Events Recorded		
	CONV	EMP	HPC
Nov 12-17	12	15	19
Nov 17-19	13	14	12
Nov 19-20	4	6	5
Nov 20-26	19	22	26
Nov 26 – Dec 2	4	5	7
Dec 2-8	7	11	24
Dec 8-17	6	5	17
Dec 17-23*	1	3	5
Dec 23-31	6	7	7
Nov 12 – Dec 31	**72**	**83**	**122**

* Conventional threshold lowered 12/23

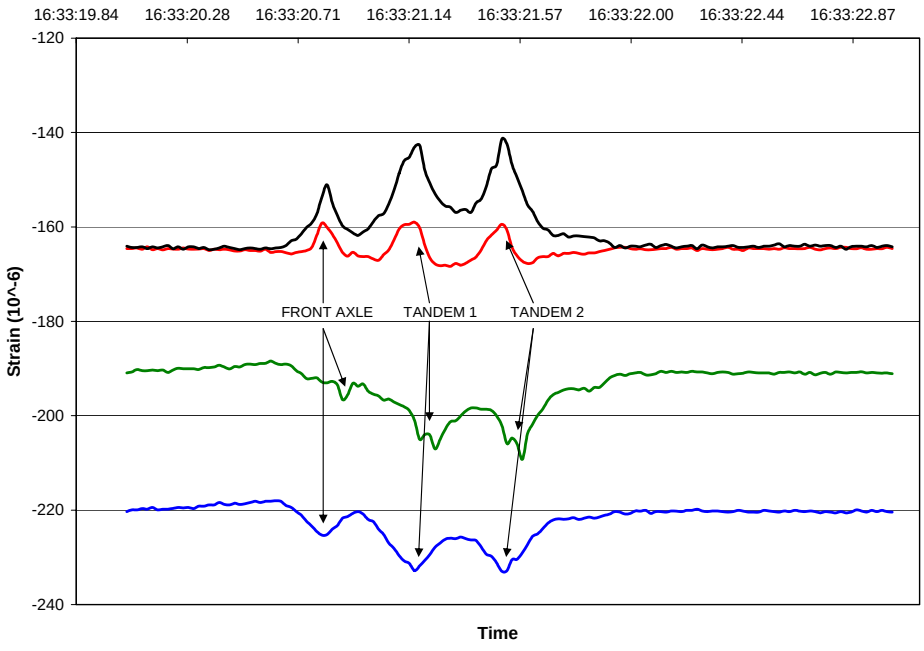

Figure 1: Typical Strain Response during a Large Vehicle Event

Corrosion Testing

Concrete carbonation tests were conducted during this quarter, in which a solution of phenolphthalein (a colorless acid/base indicator that turns purple when the pH is above 9) was used to detect the presence of carbonation – $Ca(OH)_2$. When this solution is blotted on a sample of concrete and it turns purple (or a shade thereof) carbonation has occurred. A concrete's resistance to carbonation is an indicator of its ability to protect embedded reinforcement from being penetrated by carbon dioxide which fuels corrosion. The pore microstructure of the concrete is how carbon dioxide penetration is facilitated.

Benchmark carbonation tests were conducted on the surface of all three bridge decks. To conduct these tests, two areas of the deck were first cleaned using an abrasive pad to remove the outer layer of applied sealer. On each deck, one test was done in the wheel path and one was done out of the wheel path. Once the area was blown free of dust, a dropper-full of phenolphthalein was blotted on the surface and allowed to absorb into the surface. In all cases, the phenolphthalein turned purple, which indicated that no carbonation had occurred at any of the locations on all three decks. These tests will be repeated when half-cell tests are conducted (March 2004).

Action Items for Next Quarter:

- Conduct 9-month half-cell and carbonation tests (March 2004)

Crack Mapping

The second crack mapping exercise was conducted by Craig Abernathy of MDT Research during the first week in November. Results from this survey showed that no new cracks had formed since the first crack survey. The next crack survey is scheduled to occur the first week in March 2004.

Action Items for Next Quarter:

- Conduct 9-month crack mapping and delamination survey (early March)

Task G: Analysis

Finite element analysis (FEA) can help characterize local and global behavior of structures. On this project, FEA has been used to model bridge deck response to two types of loading: vehicular and environmental. Vehicle loads are often viewed as being transmitted first transversely through the deck into the stringers and then longitudinally into the supporting structure. Laboratory tests conducted as part of a related, but separate, project investigated the transverse load carrying behavior of a bridge deck section. A finite element model (FEM) was generated to analyze this laboratory beam. Ultimately, the FEM will be extended to simulate the response of the bridge deck during live-load testing. Results from the FEM will be directly

compared to strain gage response in the test beam and eventually to the strains experienced in the bridge deck slab during live load testing.

Environmental changes also generate significant levels of strains within the bridge deck. To look at this more closely, a quarter section of the bridge deck is being modeled using a solid FEM to study the effects of temperature changes on the deck. These comparisons will be made with respect to seasonal and daily fluctuations experienced by each of the deck designs.

Action Items for Next Quarter:

- Continue refining finite element analyses
- Organize and analyze long-term strain data

Task H: Project Reporting

An interim report will be written that summarizes all of the activities and data collected as part of this research through December 2003. This report will be delivered to MDT in February of 2004.

Action Items for Next Quarter:

- Quarterly progress report for third quarter for state fiscal year 2004
- Finish interim report due February 2004